

APPARATUS FOR FILTERING AND SEPARATING FLUIDS

BACKGROUND OF THE INVENTION

The invention relates to an apparatus for filtering and separating fluids, preferably of salt-containing liquids, particularly on the basis of the principle of ultrafiltration. The apparatus comprises a pressure housing with an inlet for the fluid and outlets for the retentate and the permeate. The housing includes a plurality of spaced filter elements in the form of membrane pillows, around which the fluid is conducted. The filter elements are arranged in the housing in separate stacks of membrane pillows, which are arranged in series in the fluid flow path.

Such an apparatus is known for example from EP-A-0 707 664. In the apparatus described in this publication, the stacks of spaced membrane pillows define together an unrestricted flow path for the fluid through the apparatus, whereby the fluid can pass through the apparatus from the inlet for the fluid to the outlet for the retentate at a relatively high speed. With this apparatus, the maximum flow rate is limited by the apparatus. In the apparatus of this publication, the filter elements are arranged in separate stacks, which are connected in series. The pump is operating at a maximum operating pressure at which the apparatus needs to be operated and a second pump for pumping the fluid at a high flow speed through the apparatus. The operation of the pump for pumping the fluid through the apparatus results in

15. limitation of maintaining the high operating pressure in combination with the pump required for pumping the fluid at high flow speed through the apparatus are problematic.

It is the object of the present invention to provide an apparatus for filtering and separating fluids wherein for generating the operating pressure in the pressure housing and for pumping the fluid to be filtered or separated through the housing only one pump is needed. The apparatus should also be easy to clean and service when this should become necessary. Also, the apparatus should be relatively simple and inexpensive to manufacture while presently known design principles are maintained. Furthermore, it should be possible to adapt the apparatus to the individual load factors of the fluid to be separated.

15. SUMMARY OF THE INVENTION

In an apparatus for filtering and separating fluids, including a pressure-tight housing having a fluid inlet, a retentate outlet and a permeate outlet, a plurality of stacks of membrane filter elements are arranged in the housing adjacent one another and aligned such that the fluid is conducted through the stacks of membrane filter elements in a series flow pattern and each stack includes a plurality of spaced membrane pillows arranged in a spiral configuration such that the fluid is conducted through the filter elements in a spiral flow pattern.

25. The apparatus of claim 1, wherein the filter elements are of the flow-through type, and the filter elements are of the flow-through type, the flow-through filter elements being filter elements which are suitable for pumping the fluid through the apparatus. In this embodiment, the filter elements are filter elements which are suitable for pumping the fluid through the apparatus.

separated as it is possible with the prior art apparatus which however requires a relatively high energy input. The fluids may be solutions from waste water treatment processes, which are rich in salts and they are present for example in animal 5 husbandry, that is, for example, pig and cattle urine but the fluid may also be sea water. For the adaptation to a particular fluid, the number of stacks and the number of membrane pil- lows in a stack can be selected as necessary.

Since the apparatus can be operated at a very high operating 10 pressure of up to 120 bar, under certain conditions, above this value, a certain pressure drop between the inlet and the outlet of the apparatus as a result of the meander-like flow path of the fluid through the stack can be accommodated.

In order to ensure that, with the present design, the 15 fluid flows through subsequent stacks in a meander-like fashion, the stacks form each a volume which is in communication with an inlet and an outlet for the fluid but which is otherwise closed. In this way, it is also ensured that the same volume flow passes through all the stacks of an apparatus.

20 In order to establish such a closed stack volume with a simple design the space is delimited preferably by a separating element which may be square or oblong and the separating element includes an inlet and an outlet preferably in the form of a slot, and with provision for a longitudinal slot in the stack. The longitudinal slot in the stack is located in the fluid channel between the separating element and the stack tube, that is, the fluid channel.

25 The membrane pillows may have a shape as desired; they are however, preferably, fitted to correspond to the shape of the meander apparatus, that is, the shape of the separating element and the stack tube, that is, the shape of the apparatus.

other membrane elements, which form the membrane pillow, is the spacer.

It is very difficult to arrange the membrane pillows in the stack in a displaced fashion such that one end of each alternate membrane pillow is always adjacent the separating element. In this way, no particular means are needed for redirecting the fluid, after passing over the side of a membrane pillow, to flow over the opposite side in the opposite direction. With such a staggered arrangement of the membrane pillows, the membrane pillows themselves form the redirecting means for the fluid.

Although, it is possible to make the membrane pillows, which basically have a relatively unstable shape, stable by suitable support structures, such stabilizing means are relatively expensive and they are also annoying during disassembly in case of damage to the membrane pillows or during servicing. Also, the provision of spacer elements as they are known from the state of the art and on which the membrane elements can be held in a stable state, has the disadvantage that the pressure drop of the fluid from the inlet of the apparatus to the outlet thereof is increased. There is also the likelihood that deposits are formed at the support points of the membrane pillows on the spacer elements, which must be avoided under any circumstances. It is therefore the object of the present invention to provide a membrane apparatus which is stable, and which is not liable to damage the membrane elements, to the membrane pillows. The stabilizing element is so designed that the membrane element is held in a tightly stretched manner also at the point of transition and the transition of the fluid from the membrane element to the spacer element.

The standardizing apparatus consists preferably of plastic, but other suitable materials may be used such as compound materials or even metal. The selection of the material for the standardizing apparatus depends largely on the type of fluid, and the fluid pressure, which is maintained in the apparatus.

It is also advantageous if annular spacer elements are used for the outer spacing of the membrane pillows. The annular spacer elements may include elastomer sealing elements, but also strip-like spacer elements could be provided for the outer membrane elements. This will facilitate the mounting of the stack of membrane pillows. The sealing elements can be formed by a separate strip ring. But, with the use of a suitable material, an annular spacer of an elastic material may provide a seal without the need for a sealing element, in addition to maintaining a certain space between the membrane pillows.

As indicated already, the membrane pillow includes at least one permeate discharge opening, but it may be advantageous to provide a plurality of permeate discharge openings in the membrane pillow. Preferably, two discharge openings are arranged at an imaginary longitudinal axis of the oblong membrane pillow at different distances from the adjacent ends of the membrane pillows. In this way the membrane pillows arranged in a stack can be displaced with respect to one another, such that a permeate discharge opening of one of the adjacent 20 membrane pillows is located in the region of a permeate discharge opening of the other membrane pillow. In this way the permeate discharge openings of adjacent membrane pillows will be located in the same longitudinal axis of the stack, respectively. The end of the membrane pillow, a membrane pillow being situated at the end of the fluid by the stack, will be closed.

Such an arrangement of the stacks has the advantage that they can be easily accommodated in the apparatus. This is particularly true if the stacks are received in two semi-circular shell elements, which enclose the stacks of membrane pillows.

5 The inner dimension of the two interconnected shell elements is preferably such that the two shell elements are assembled. The dimensions are preferably so selected that the stack of membrane elements is tightly engaged between the two semi-circular shell elements. The membrane pillow can then, in 10 cooperation with the spacer elements disposed therebetween, ensure that no additional mounting bolts or similar elements are necessary to keep the permeate discharge openings of the membrane pillow sealing while maintaining a predetermined distance between the membrane pillows for the flow of fluid therebetween.

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Finally, the shell elements includes a permeate discharge channel, which extends longitudinally through the shell element and which is in communication with permeate discharge openings leading to the inner bottom area of the shell elements. With 20 this arrangement, the permeate discharge channel is formed integrally with the shell element which has the additional advantage that the need for separate discharge structures is eliminated, which reduces overall expense for the apparatus.

Another advantage of this arrangement is that the fluid and 25 permeate discharge areas are completely separated, so that no mixing, separation or mixing of the two fluids is required.

FIG. 1 is a simplified, front-sectional view of a fluid filtering and separating apparatus with two stack shells, each containing a stack of membrane pillows and semi-circular shell elements.

Fig. 2 and Fig. 3 show the flow structure through two adjacent slanted and moving plates (Fig. 1).

Fig. 4a. In a plan view, the separating element for dispersion between two stacks of methacrylate pillows.

Fig. 11. GR and a self-replicating 1D lattice separating element shown in Fig. 1, 3a.

Fig. 5 shows schematically a membrane pillow as used in the apparatus and related to the intention with two permeate discharge points at different sides of the narrow side of the membrane pillow.

Fig. 6a is a side view of a disc-shaped spacer element, and

Fig. 6b is a front view of the disc-shaped spacer element shown in Fig. 6a.

DESCRIPTION OF A PREFERRED EMBODIMENT

As shown in Fig. 1, the apparatus 10 for filtering and separating fluids consists essentially of a housing 11 which is closed and sealed at opposite ends by closure elements 110, 111 in a pressure tight manner. As circumferential sealing means 112, 113, for example, O-rings may be used. The closure element 110 includes an inlet 12 for the fluid 15 to be supplied to the apparatus 10. The opposite closure element 111 includes an outlet 13 for the separated fluid 16, which is called the retentate, and an outlet 14 for the filtrate. The housing 11 is provided with a top access port 17 and a bottom access port 18. The top access port 17 is provided with a top access closure 19. The bottom access port 18 is provided with a bottom access closure 20. The top access closure 19 and the bottom access closure 20 are each provided with a handle 21 and a handle 22, respectively, for opening and closing the top access closure 19 and the bottom access closure 20.

are contained in the stack and are to be separated therefrom. Apparatus with the stack, stack members and after the latter have already been described.

The stack 16 is shown in a later view identical so that only 5 the stack itself will be described below. As shown in Fig. 2, the stack consists of a stack of two shell elements 18, 20. The shell elements 18, 20 have a semi-circular circumference. In the interface, they are essentially rectangular such that two elements when arranged form an inner space of essentially 10 square cross-section. The shell elements 18, 20 may be interconnected by fastening means which are not shown in the drawing. It may be for example a removable bolt and nut joint. Two shell elements engage between them, in a tight manner, a stack 16, which is formed by a plurality of spacer element 16 and by membrane pillows 17 - see Figs. 2, 6a, and 6b. The mem- 15 brane pillows 17 are arranged between the spacer elements 16. Such membrane pillows as they are used in the apparatus 16 for forming the stacks 16 together with the spacer elements 16 are disclosed for example in EP-2-119 061.

20 Since the membrane pillows 17 used in the apparatus 16 are known as to their construction from the aforementioned document, they are not described herein in detail. The known mem- brane pillows 17, however, are somewhat modified for use in the apparatus 16. Referring to the drawings, the stack 16 is composed 25 of a plurality of shell elements 18, 20 and a plurality of spacer elements 16. The spacer elements 16 are arranged between the shell elements 18, 20, and the spacer elements 16 are arranged between the membrane pillows 17. The spacer elements 16 are shown in Fig. 2 by dashed lines. The shell elements 18, 20, and the spacer 16 are plastic mate- 30 rials, the shell elements 18, 20 being polypropylene and the spacer 16

The spacer elements 16 are disposed in the encasements 15 of the apparatus 11 as shown in the figures. Preferably, they consist of an elastomeric material such as rubber or of a corresponding suitable plastic material. The spacer element 16 is inserted in position into a cavity 17 in side to the permeate discharge openings 114, 115 in the membrane pillow 17. For clarification, Fig. 6 is shown at an enlarged scale with respect to Fig. 5. The spacer element 16 provides a seal between two membrane pillows 17 as a result of the shape of the spacer element 16 itself or, additionally or alternatively, by a sealing element 163 shown in Fig. 6b by a dashed-dotted line representing for example an O-ring extending around the spacer element 16. The spacer element therefore forms a seal between two membrane pillows 17 between which it is engaged and determines also the distance between the two adjacent membrane pillows 17, which distance is established by its thickness. When the membrane pillows 17 are tightly stacked in a stack 18 with the spacer elements 16 disposed tightly between adjacent membrane pillows as shown in Fig. 5, no fluid 15 can escape to the permeate discharge openings 114, 115, because the spacer elements 16 form tight seals if necessary in cooperation with sealing element 163 as indicated in Fig. 6b.

leaves the membrane cell, with the way of the permeate discharge being Fig. 14, the permeate is conducted away and flows through the permeate discharge pipe (Fig. 14), to the permeate discharge tank.

5 The stack is desirably made of a single set between two shell
 elements 18, 19 in a tight manner by fastening means which have
 been omitted for clarity. When the shell elements 18, 19 are
 joined together it is made sure that the permeate separated by the per-
 10 meate filter 17 passes 17 passes the permeate pillows through the
 permeate discharge openings of the membrane pillows 17 by way
 of the openings 23 of the spacer elements 16, the permeate
 discharge pillows of the drain 164 and the permeate dis-
 charge openings 23, 24 of the shell elements 18, 19. The per-
 15 meate is collected in the permeate discharge channels 22 of the
 shell elements 18, 19 and conducted from there to the permeate
 outlet 14 of the apparatus. All adjacent stack shells 27, 270
 - in the example only two stack shells are shown - are remova-
 bly interconnected by suitable connecting means incorporated
 20 into the stack shells 27, 270. These connecting means may be
 for example plastic caps, sealing elements arranged between
 the adjacent stack shells providing for a pressure tight fluid
 flow path with respect to the flow path of the permeate gener-
 ated in the apparatus 11.

The membrane pillows 17 are arranged in each stack 16 in such a way that the fluid 11 flows around the membrane pillows in a meander-like pattern, see the flow pattern of two serially arranged stacks as shown in FIG. 3a, b. The membrane pillows 17 are arranged such that the two permeate discharge openings 174, 175 are arranged at different distances 179, 179' from the ends 176, 177 of the membrane pillows 17. The larger distance 179' of the permeate opening 175 from one end 176 of the membrane pillow as shown in FIG. 3b on the right ensures that the membrane pillow 17 abuts the separating element 31. The smaller distance 179 of the permeate discharge opening 174 from the other end 177 of the membrane pillow 17, which is shown in FIG. 3a at the left provides for a space between the end 176 of the membrane pillow 17 and the separating element 31 thereby forming a fluid flow reversal path around the end 176 of the membrane pillow 17. With an alternate stacking of the membrane pillows 17 wherein each second membrane pillow 17 is turned by 180°, each second membrane pillow abuts with one end 177 the separating element 31. The same applies to the other end 176 where each first membrane pillow 17 engages the respective separating element 31 of FIG. 2a. The fluid entering a stack 16 of membrane pillows 17 through the slit-like inlet 160 of the separating element 31 (see FIG. 3a, b) is guided by the membrane pillows 17 and the fluid 11 is directed around the membrane pillows 17 and the separating element 31. The fluid 11 is then directed through the membrane pillows 17 and the separating element 31, wherein also a fluid inlet 160 for the next stack 16 is formed.

Opposite to the first stack 16, the apparatus 10 is provided with a second stack 16, which is arranged in a similar manner as the first stack 16.

Then the plurality of stack shells 27 which are interconnected one inserted into an opening in the housing 11. It is made sure that the periphery of the channels 22 of the stack shells 27 are buried in a peroxide-tight material and are continuous from the last stack shell 27 to a corresponding opening of the closure element 111 of the housing 11. Then the housing 11 is closed by the opposite closure element 110. The closure elements are locked in position by the locking rings 115 and 114 respectively, whereby it is made sure that any axial movement of the plurality of interconnected stack shells 27 in the housing 11 is prevented.

Subsequently, for the operation of the apparatus 10, the fluid 15 is introduced into the apparatus 10 by way of the inlet 12 and reaches the space 30 by way of the inlet 160 of the separating element 51 of the first stack 18. In the space 30, the fluid 15 flows around the membrane pillows 17 in a meander-like pattern to the outlet 161 of the first stack 18. The outlet 161 of the first stack 18 forms the inlet 160 of the separating element 51 of the second stack 18 so that the fluid 15 is conducted into the second stack 18. In the second stack, the fluid 15 again meanders past the plurality of membrane pillows 17. After passing through all the serially arranged stacks 18 the concentrate fluid 16, which is the peroxide, leaves the apparatus 10 and the apparatus 10 is flushed with a dilute acid.

The apparatus 10 is flushed with a dilute acid of 1% HCl in a separating element 51, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160, 161, 162, 163, 164, 165, 166, 167, 168, 169, 170, 171, 172, 173, 174, 175, 176, 177, 178, 179, 180, 181, 182, 183, 184, 185, 186, 187, 188, 189, 190, 191, 192, 193, 194, 195, 196, 197, 198, 199, 200, 201, 202, 203, 204, 205, 206, 207, 208, 209, 210, 211, 212, 213, 214, 215, 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996, 997, 998, 999, 990, 991, 992, 993, 994, 995, 996, 997, 998, 999, 1000, 1001, 1002, 1003, 1004, 1005, 1006, 1007, 1008, 1009, 1000, 1001, 1002, 1003, 1004, 1005, 1006, 1007, 1008, 1009, 1010, 1011, 1012, 1013, 1014, 1015, 1016, 1017, 1018, 1019, 1010, 1011, 1012, 1013, 1014, 1015, 1016, 1017, 1018, 1019, 1020, 1021, 1022, 1023, 1024, 1025, 1026, 1027, 1028, 1029, 1020, 1021, 1022, 1023, 1024, 1025, 1026, 1027, 1028, 1029, 1030, 1031, 1032, 1033, 1034, 1035, 1036, 1037, 1038, 1039, 1030, 1031, 1032, 1033, 1034, 1035, 1036, 1037, 1038, 1039, 1040, 1041, 1042, 1043, 1044, 1045, 1046, 1047, 1048, 1049, 1040, 1041, 1042, 1043, 1044, 1045, 1046, 1047, 1048, 1049, 1050, 1051, 1052, 1053, 1054, 1055, 1056, 1057, 1058, 1059, 1050, 1051, 1052, 1053, 1054, 1055, 1056, 1057, 1058, 1059, 1060, 1061, 1062, 1063, 1064, 1065, 1066, 1067, 1068, 1069, 1060, 1061, 1062, 1063, 1064, 1065, 1066, 1067, 1068, 1069, 1070, 1071, 1072, 1073, 1074, 1075, 1076, 1077, 1078, 1079, 1070, 1071, 1072, 1073, 1074, 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